BIOLOGICAL EVALUATION OF GYPSY MOTH AT BLACKWATER NATIONAL WILDLIFE REFUGE, 1996-97

Prepared by

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ABSTRACT

On November 5-7, 1996, USDA Forest Service personnel conducted a gypsy moth egg mass survey at Blackwater National Wildlife Refuge. The purpose of the survey was to determine population densities to evaluate the efficacy of the 1996 treatment areas and assess the potential for defoliation and the need for treatment in 1997. Current populations are sufficient to cause at least moderate defoliation on 1,381 acres in 1997. In order to protect Delmarva fox squirrel habitat, treatment is recommended for this area using Gypchek.

METHODS

The survey area consisted of all stands that were treated in 1996 and in stands that were previously identified as being fair or good fox squirrel habitat with a high potential for gypsy moth defoliation (Whiteman and Onken, 1994). The survey was also conducted in the newly acquired Rasch tract (Stand 69) and Lake tracts (Stands 67 and 68).

Within each stand, gypsy moth survey plots were randomly selected based upon available host trees (oak and sweet gum), size of sample area, and uniformity between egg mass counts. At each sample point, a 1/40th acre fixed radius plot was established. The plots consisted of a tally of all the new (1996) and old (1995) egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by the percentage of new egg masses and then by 40 to determine egg masses per acre (Liebhold et al., 1994).

Egg mass length at a number of the plots was measured to determine the overall "health" of the existing population and as a measure of egg mass fecundity. The average egg mass length (measured in millimeters) and egg mass density (egg masses per acre) was used to estimate defoliation potential (Liebhold et al., 1993).

RESULTS

The 30 stands surveyed are presented in Figure 1-2D and summarized in Table 1. Throughout the survey area, egg mass densities range from 0 to 7,600 and average 1,299 egg masses per acre. Ten stands have egg mass densities that average less than the treatment threshold of 750 egg masses per acre, while 16 stands average between 750-2000 and four stands average more than 2,000 egg masses per acre. Egg mass size is variable throughout the survey area and ranges from 19 to 25 mm and averages 22 mm long. A total of 1,381 acres have egg mass densities exceeding the treatment threshold of 750 egg masses/acre.

Egg mass survey results for the 23 stands (896 acres) treated in 1996 are summarized in Table 2. Overall, the average egg mass density was reduced 56 percent from the pre-treatment level of 2,997 to the current level (post-treatment) of 1,324 egg masses per acre. Although egg mass densities decreased by more than 50 percent in 14 stands, egg mass densities actually increased in two of the treated stands. The treatment area is shown in Figure 3 as is the 93 acres of defoliation that occurred at the refuge. A total ot 22 acres (2 percent) of the treatment area was defoliated.

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include: previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food; and risk of larval blow-in following egg hatch. Potential defoliation is categorized as: light (1-30 percent); moderate (31-60; and heavy (61-100 percent).

Gypsy moth populations are sufficient to cause moderate to heavy defoliation throughout much of Stands 4, 12, 21, 23, 27, 29, 32, 33, 34, 35, 37, 38, 39, 44, 56, 57, 58, 63, 67 and 68. These 20 stands encompass 1,381 acres and have an average egg mass density of 1,638 egg masses per acre. Only small and isolated areas of noticeable defoliation, if any, are likely elsewhere at Blackwater National Wildlife Refuge in 1997.

Based on the average length of egg masses (22 mm) at the Refuge, the overall health of the gypsy moth population appears marginal. Generally, egg mass lengths of less than 20 mm are associated with low fecundity, which normally relates to a stressed, declining population. Egg mass lengths greater than 24 mm tend to indicate a healthy, building population. Populations at Blackwater National Wildlife Refuge are such that the previous generation was likely stressed but not quite enough to trigger a decline. In any case, egg mass densities are sufficient to cause defoliation prior to the collapse of this population. This conclusion is further supported when egg density is used as a means of predicting defoliation. Moore and Jones (1987) found that estimating the mean fecundity will increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al. (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. Using Liebhold's model, Figure 4 shows how this information can be used to correlate the predicted defoliation. Accordingly, the estimated egg mass density of 1638 egg masses per acre x 22 mm (average egg mass length) translates to a projected defoliation level of about 38 percent (moderate defoliation). This estimate represents an overall average and because egg densities and host type are not evenly distributed, actual defoliation will range from light to heavy throughout the area.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. A more immediate and direct effect of defoliation on fox squirrel populations is through the loss of oak mast. This occurs primarily from caterpillar feeding damage to flowers as well as the foliage. Excessive foliage loss causes a lack of carbohydrates which results in the abortion of immature acorns. It is possible to have up to 5 years of complete acorn failure during and following years of moderate to heavy defoliation (Gottschalk, 1990).

In general, trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light-moderate defoliation (<60 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems. Previous gypsy moth-caused defoliation occurred at Blackwater NWR in 1993 (598 acres), 1994 (988 acres), 1995 (116 acres) and 1996 (93 acres). Droughty conditions also occurred throughout the Eastern Shore in 1993 and 1995.

An example of the potential tree mortality that could occur is provided by the Allegheny National Forest. In untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28 percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In this example, droughty conditions likely contributed to the level of mortality.

The potential loss of acorn mast was demonstrated by McConnell in 1988 (Gottschalk, 1990). His study found that moderate defoliation reduced production by about 50 percent and heavy defoliation near 100 percent. Other studies conducted by the Pennsylvania Game Commission had similar results and found that reduced acorn production continued for 1-2 years following the last year of defoliation.

The past year's (1996) project using a double application of *B.t.k.* on 896 acres was successful in preventing widespread defoliation but only marginally successful in reducing population densities. Foliage protection was provided for approximately 98 percent of the project area and the average egg mass density for the project area was reduced approximately 56 percent. Unfortunately, approximately 76 percent of the treatment area still has egg mass densities that exceed the treatment threshold of 750 egg masses per acre and warrant treatment in 1997.

Management Options

For 1997, two management options have been evaluated for managing gypsy moth populations at Blackwater National Wildlife Refuge. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent mast failures and tree mortality; and 2) reduce gypsy moth populations below the treatment threshold of 750 egg masses per acre. Each is discussed below and considers the primary resource management objective of protecting Delmarva fox squirrel habitat.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) and/or the more recently recognized fungal pathogen, *Entomophaga maimaiga*. In areas with defoliating level gypsy moth populations (greater than 750 egg masses per acre) viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels. Although it is not possible to accurately assess such events with the information at hand, it is likely that a collapse will occur throughout most of the area at the Refuge in the next year or two. However, it is likely that these stands will be defoliated before this event.

Should this option be selected, it is likely that defoliation will occur on most of the 1,381 acres of the Refuge in 1997.

Microbial Insecticide Option

B.t.

The second option is to use a microbial insecticide to manage gypsy moth populations. The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringiensis* variety *kurstaki* (*B.t.k.*). This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *B.t.k.* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore

must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *B.t.k.* has been shown to impact other non-target caterpillars that are exposed to the treatment and are actively feeding. *B.t.k.* is persistent on foliage for about 7-10 days.

B.t.k. formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double applications. *B.t.k.* can be applied either undiluted or mixed with water for a total volume of 1/2-1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely. Because *B.t.k.* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek

The nucleopolyhedrosis virus (NPV) product, Gypchek, is another microbial insecticide that can be used. Gypchek is not yet available commercially, but the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS) has registered and produced the product in limited quantities. The NPV is host specific and occurs naturally in gypsy moth populations. Normally, the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations.

To date, the efficacy of Gypchek treatments to reduce gypsy moth populations has been somewhat variable. Because of the short period of viral activity on foliage (5-6 days) as well as other biological factors such as feeding activity and weather conditions, it is difficult to predict treatment efficacy. Given the existing egg mass densities and the somewhat stressed populations at the Refuge, we expect adequate foliage protection and believe sufficient population reduction will occur under this option.

The standard 2 gallon per acre application rate of Gypchek is $2x10^{11}$ occlusion bodies (OBs) per acre. In addition to the virus the formulation includes a carrier consisting of unchlorinated water, ProMo® molasses which serves as a feeding stimulant, Lignosite® AN that acts as a sunscreen and Bond® sticker to help deposition adhere to the foliage in a total mix of 2 gallons per acre. The treatment requires that two applications be applied three days apart.

Alternatives

With the previously described options in mind, the following three (3) alternatives are offered.

Alternative 1.	--	No action.
Alternative 2.	--	One aerial application of *B.t.k.* at the rate of 36 BIUs in a total mix of 3/4 gallon per acre.
Alternative 3.	--	Two aerial applications of Gypchek applied at the rate of $2x10^{11}$ OBs in a total mix of 2 gallons per acre. The application should be applied 3 days apart.

RECOMMENDATIONS

As previously stated, gypsy moth populations are sufficient to cause areas of moderate and heavy defoliation. In order to protect tree foliage, mast production, and prevent tree mortality, our recommendation is a double application of Gypchek (Alternative 3) in 20 stands covering 1,381 acres (Figure 5).

Alternative 3 is recommended based on the following considerations:

1) Based on the egg mass densities encountered and the marginal health of gypsy moth populations in most of the stands, a double application of Gypchek will provide foliage protection and likely reduce populations below the treatment threshold.

2) Gypchek is host specific.

3) *B.t.k.* has been used for three consecutive years at the Refuge and the use of Gypchek would mitigate further impacts to non-target lepidopterous species.

REFERENCES

Gottschalk, K.W. 1990 Gypsy Moth Impacts on Mast Production, IN: McGee, Charles E. ed. Proceedings of the Workshop, Southern Appalachian Mast Management; 1989 August 14-16; Knoxville TN: University of Tennessee; 42-50.

Liebhold,A.M., Simons, E.E., Sior,A., and Unger,J.D. 1993. Forecasting defoliation caused by the gypsy moth from field measurements. Environ.Entomol. 22(1):26-32.

Liebhold,A.M., Thorpe,K., Ghent,J. and Lyon,D.B. 1994. Gypsy moth egg mass sampling for decision-making: a user's guide. USDA Forest Service, NA-TP-04-94

Moore,K.E.B. and Jones,C.G. 1987. Field estimation of fecundity of gypsy moth (Lepidoptera:Lymantriidae). Envirin. Entomol. 16:165-167.

Whiteman, R.L., and B.P. Onken, 1994. Protecting Delmarva Fox Squirrel Habitat from Gypsy Moth and Southern Pine Beetle, Blackwater National Wildlife Refuge, 1994. Unpublished Report, 46pp.

Table 1.--Gypsy moth egg mass survey results at Blackwater National Wildlife Refuge, November 5-7, 1996.

Stand Number	Plot Number	Number EM/Acre
4	1	3160
4	2	800
4	3	3760
4	4	5200
4	5	1600
4	6	1880
		Range=800-5200
		Average=2733
7	7	40
7	8	880
		Range=40-880
		Average=460
10	9	440
10	10	360
		Range=360-440
		Average=400
11	11	0
11	12	160
		Range=0-160
		Average=80
12	13	1360
12	14	200
12	15	1400
12	16	0
12	17	920
12	18	1920
12	19	920
12	20	2600
12	21	3880
		Range=0-3880
		Average=1467
21	22	1640
21	23	1480
21	24	760
		Range=760-1640
		Average=1293

Stand Number	Plot Number	Number EM/Acre
23	25	2840
23	26	2920
23	27	160
		Range=160-2920
		Average=1973
27	28	1960
27	29	7600
27	30	360
		Range=360-7600
		Average=3287
29	31	40
29	32	1920
29	33	720
29	34	2800
29	35	800
29	36	1320
		Range=40-2800
		Average=1267
32	37	360
32	38	1880
32	39	1600
		Range=360-1880
		Average=1280
33	40	1360
33	41	800
		Range=800-1360
		Average=1080
34	42	1520
34	43	320
		Range=320-1520
		Average=920
35	44	1680
35	45	1080
35	46	1360
35	47	3440
35	48	3560
35	49	880
		Range=880-3500
		Average=2000

Table 1.--Gypsy moth egg mass survey results at Blackwater National Wildlife Refuge, November 5-7, 1996 (continued).

Stand Number	Plot Number	Number EM/Acre
37	50	680
37	51	3960
37	52	320
37	53	1680
		Range=320-3960
		Average=1660
38	54	2120
38	55	1680
		Range=1680-2120
		Average=1900
39	56	2760
39	57	280
		Range=280-2760
		Average=1520
40	58	200
41	59	720
41	60	160
		Range=160-720
		Average=440
44	61	2520
51	62	0
51	63	0
		Average=0
56	64	1480
56	65	3320
56	66	3920
56	67	440
		Range=440-3920
		Average=2290
57	68	1160
58	69	920
58	70	3400
58	71	0
58	72	400
		Range=0-3400
		Average=1180
61	73	400
61	74	0
61	75	920
61	76	160
61	77	1400
		Range=0-1400
		Average=576
63	78	1160
63	79	360
		Range=360-1160
		Average=760
64	80	160
64	81	480
64	82	0
64	83	1640
		Range=0-1640
		Average=570
65	84	0
65	85	0
65	86	0
65	87	0
		Average=0
67	88	400
67	89	2040
67	90	520
67	91	640
67	92	2640
67	93	800
67	94	320
67	95	1280
		Range=320-2640
		Average=1080

Table 1.--Gypsy moth egg mass survey results at Blackwater National Wildlife Refuge, November 5-7, 1996 (continued).

Stand Number	Plot Number	Number EM/Acre
68		96 920
68		97 1880
68		98 3480
68		99 1560
68		100 320
68		101 200
		Range=200-3480
		Average=1393

Stand Number	Plot Number	Number EM/Acre
69		102 120
69		103 480
69		104 680
		Range=120-680
		Average=427

Overall Range = 0-7600
Overall Average = 1299

Table 2.--Comparison of pre-treatment and post-treatment egg mass densities at Blackwater National Wildlife Refuge.

Stand Number	Average Egg Masses/Acre 1995 (Pre-treatment)	Average Egg Masses/Acre 1996 (Post-treatment)	Percent Change
21	4480	1293	-71
23	8840	1973	-78
27	3293	3287	0
29	2060	1267	-38
32	1360	1280	-6
33	3100	1080	-65
34	2840	920	-68
35	4160	2000	-52
37	3680	1660	-55
39	2100	1520	-28
40	2700	200	-93
41	1960	440	-78
44	3240	2520	-22
51	2300	0	-100
56	4740	2290	-52
57	7740	1160	-85
64	1840	570	-69
65	2267	0	-100
4*	1500	2573	72
7*	1000	460	-54
12*	1720	986	-43
38*	1440	2120	47
63*	1480	760	-49
All Treated Stands	2997	1324	-56

*Egg mass densities reflect only that portion of the stand treated.

Figure 1. -- Stands surveyed for gypsy moth egg masses at Blackwater National Wildlife Refuge, November 5-7, 1996.

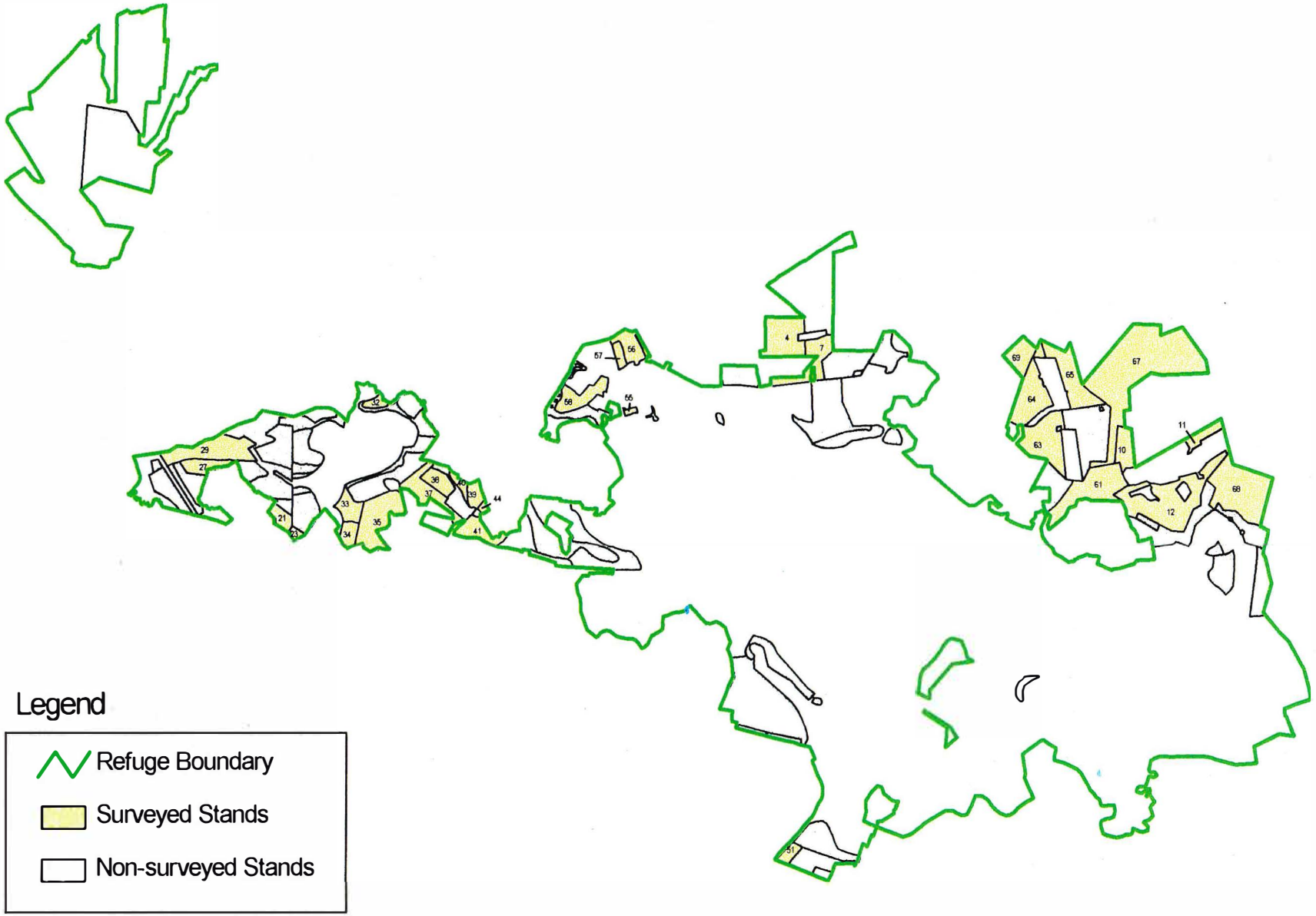


Figure 2a. -- Gypsy moth egg mass survey plot locations at Blackwater National Wildlife Refuge, November 5-7, 1996.

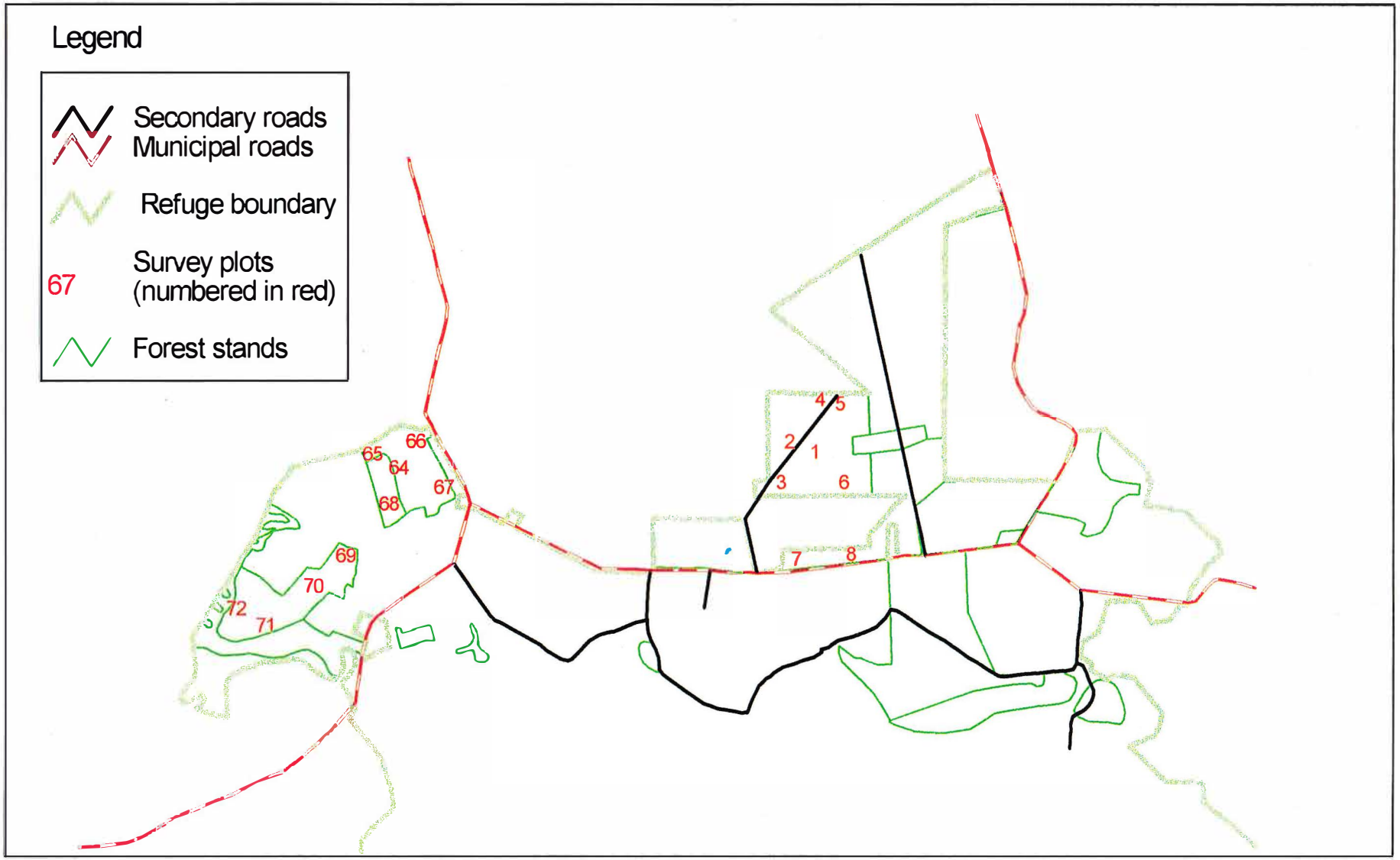


Figure 2b. -- Gypsy moth egg mass survey plot locations at Blackwater National Wildlife Refuge, November 5-7, 1996.

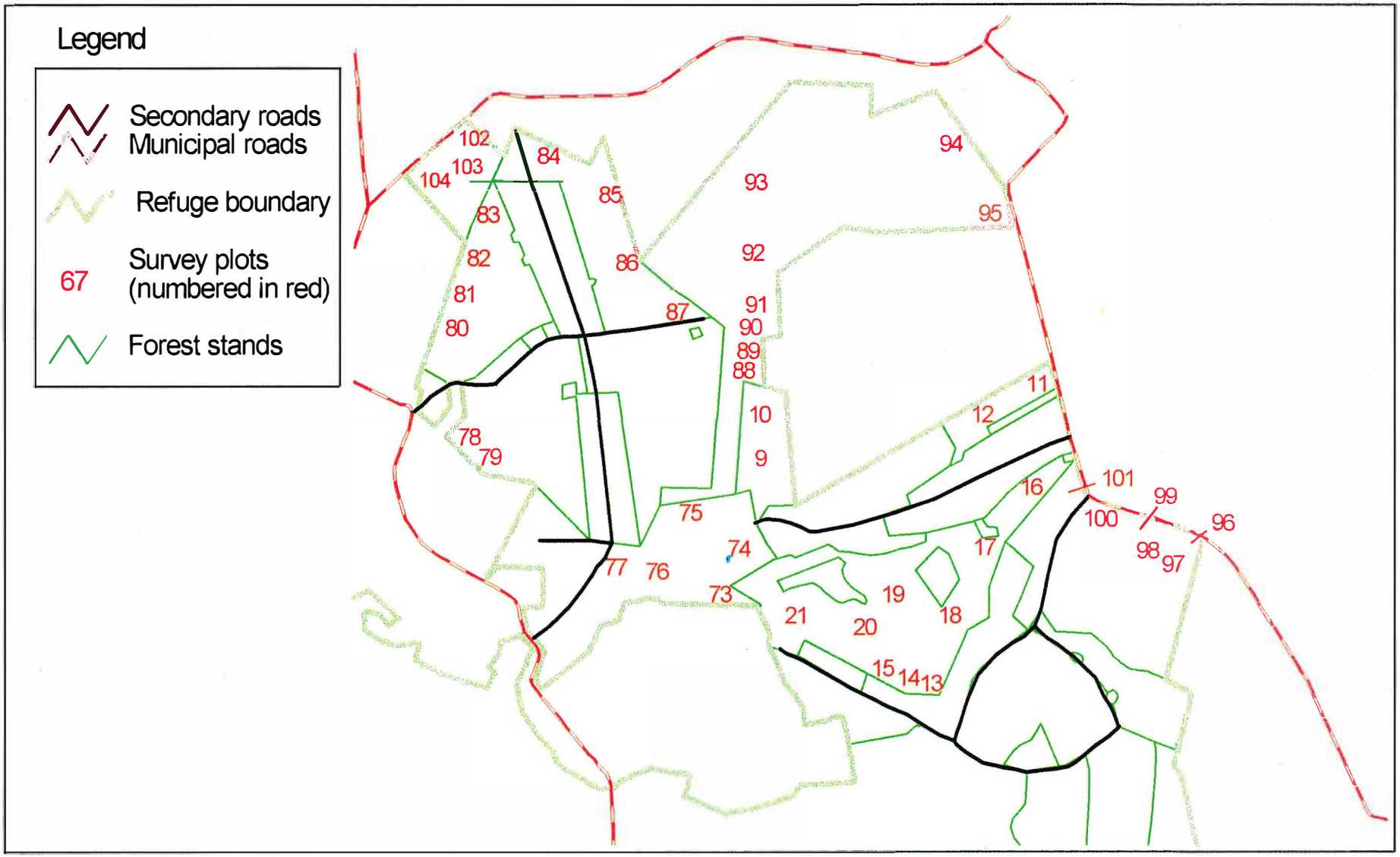


Figure 2c. -- Gypsy moth egg mass survey plot locations at Blackwater National Wildlife Refuge, November 5-7, 1996.

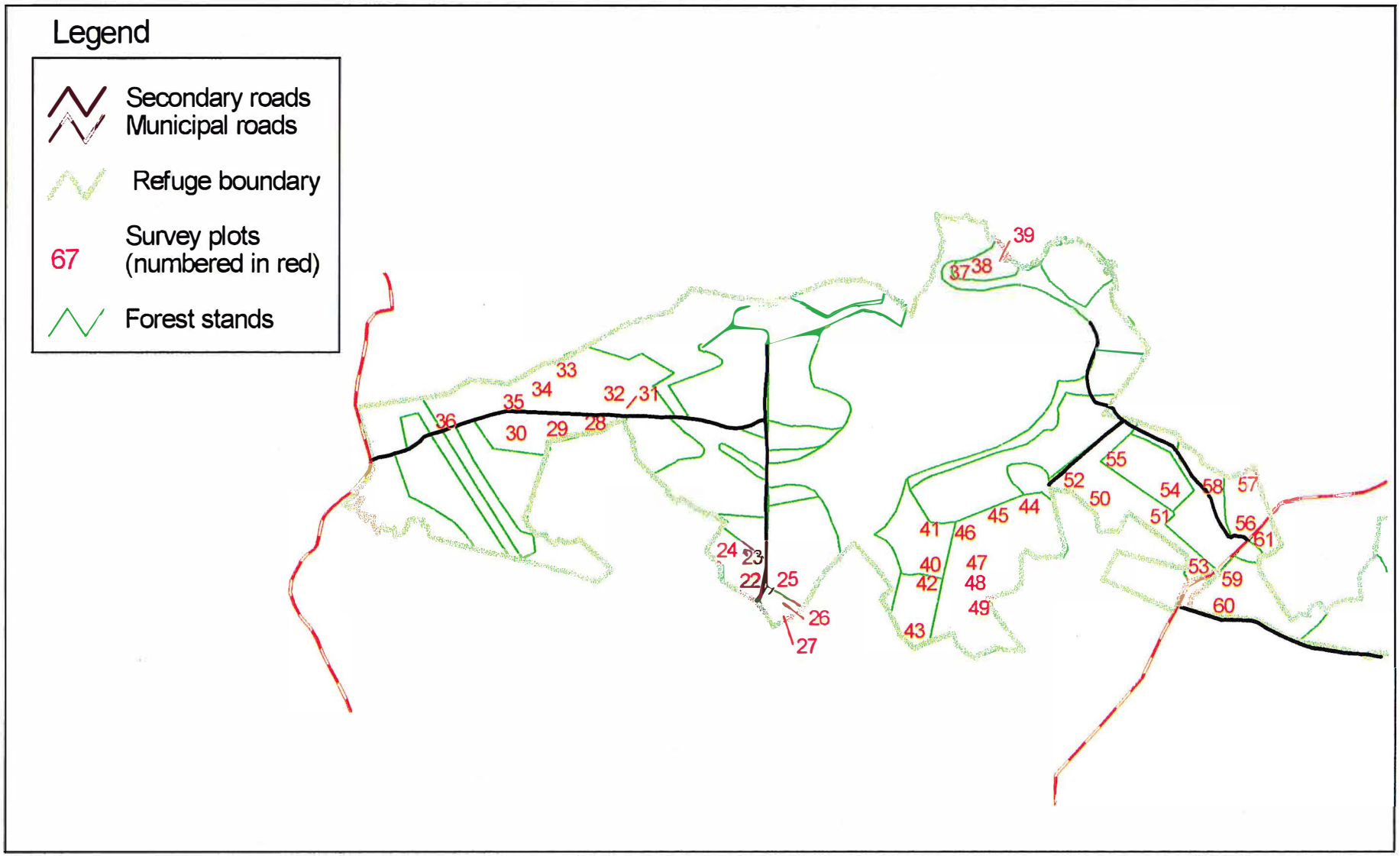


Figure 2d. -- Gypsy moth egg mass survey plot locations at Blackwater National Wildlife Refuge, November 5-7, 1996.

Figure 3. -- Location of the 1996 gypsy moth treatment blocks and the results of the gypsy moth defoliation survey conducted on June 17, 1996, at and near Blackwater National Wildlife Refuge.

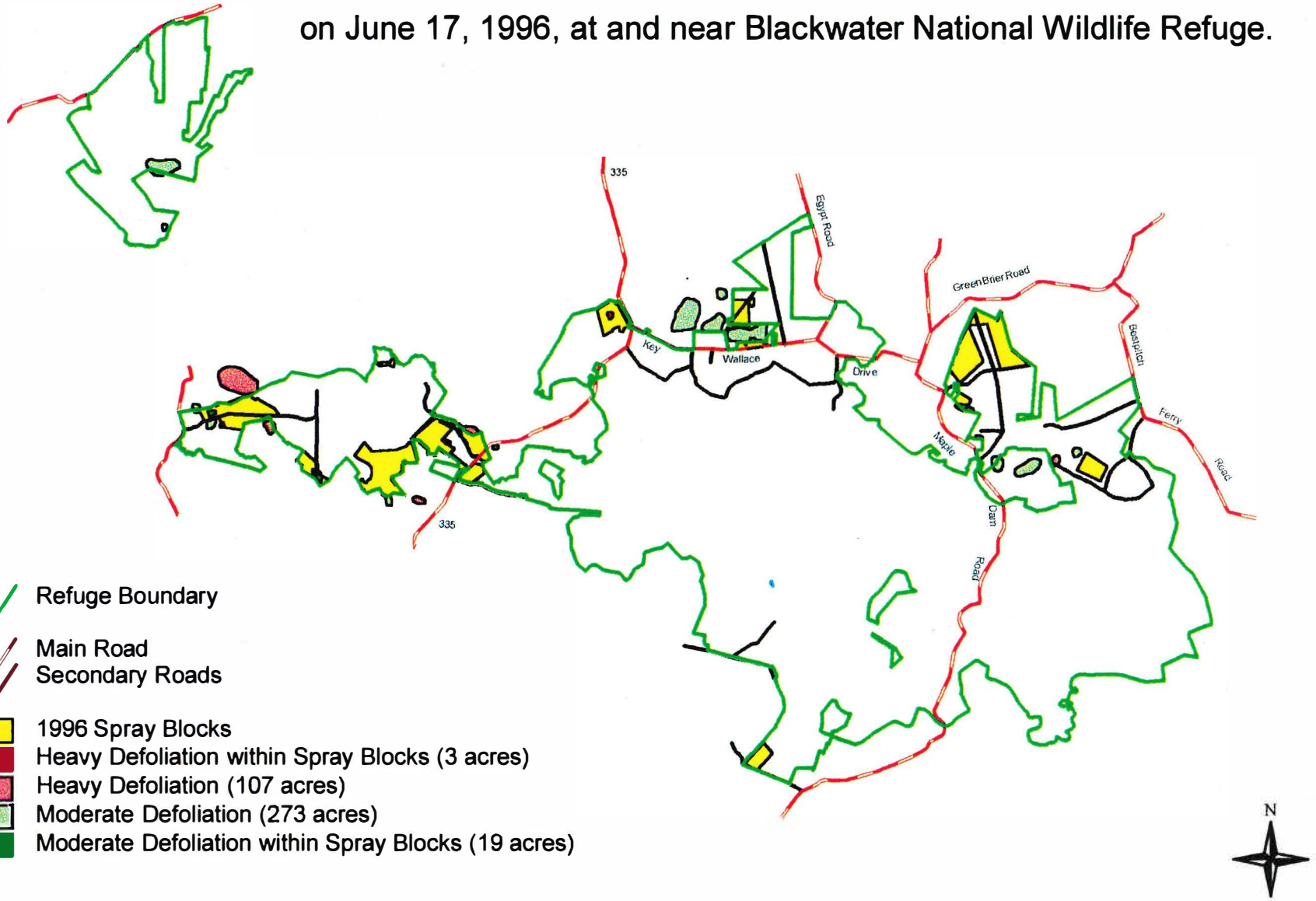
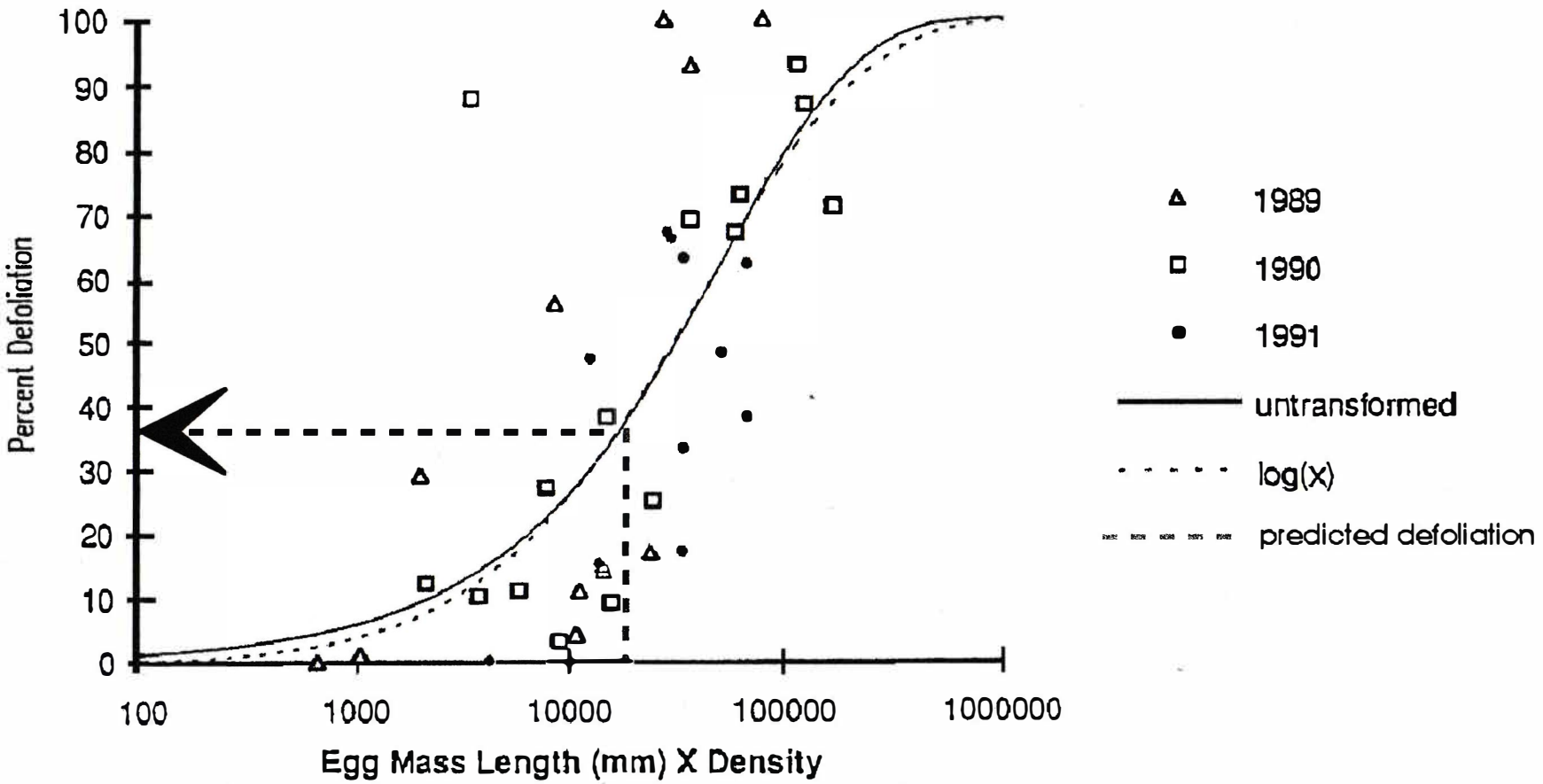
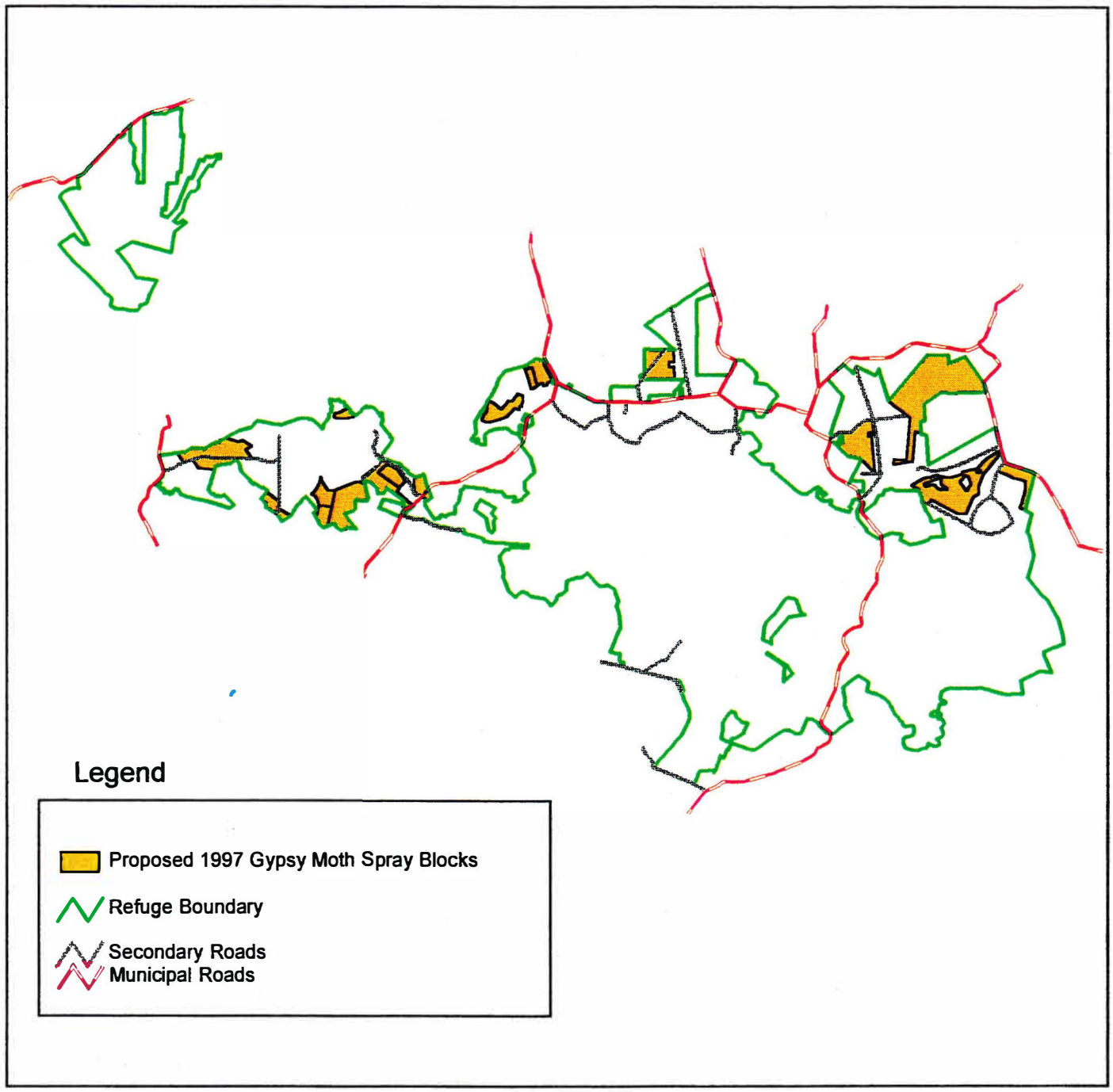


Figure 4.--Predicted defoliation in 1997 at Blackwater National Wildlife Refuge based on egg mass length and density.



Scatter plot of the product of mean egg mass length and egg mass density versus mean defoliation. Extracted from Liebhold et al. (1993).

Figure 5. -- Proposed 1997 gypsy moth spray blocks at Blackwater National Wildlife Refuge.



United States Department of Agriculture | Forest Service | Northeastern Area State & Private Forestry | 180 Canfield Street Morgantown, WV 26505-3101

File Code: 3460

Date: February 28, 1997

Glenn Carowan, Refuge Manager
USDI Fish and Wildlife Service
Blackwater National Wildlife Refuge
2145 Key Wallace Drive
Cambridge, MD 21613

Dear Glenn:

Enclosed is the gypsy moth biological evaluation supporting this year's suppression efforts at Blackwater National Wildlife Refuge.

We have recommended the use of the nucleopolyhedrosis virus (Gypchek) to prevent defoliation and protect 1,381 acres of forest land managed for Delmarva fox squirrel habitat. This recommendation is based on the following considerations:

1. Both egg mass densities and the general health of gypsy moth populations are such that Gypchek will provide foliage protection and likely reduce populations below treatment thresholds;

2. Gypchek is host specific; and

3. B.t.k. has been used for three consecutive years at the Refuge and the use of Gypchek will mitigate further impacts to non-target lepidopterous species.

The results of the 1996 suppression efforts were somewhat disappointing. We succeeded in preventing defoliation on 98 percent of the treated area, but about 76 percent (680 acres) of the area qualified for treatment again this year. Limited to using microbial insecticides only, it has become obvious that we cannot expect a sufficient population reduction when treating high density, health populations. Fortunately, current densities are less than half of what they were last year and the general health of the population appears to be marginal.

Keep your fingers crossed and maybe this will be our last treatment at Blackwater for a few years!

Sincerely,

Brad Onken

BRADLEY P. ONKEN
Entomologist
Forest Health Protection

Enclosure

cc: AO
Bob Tichenor
Allen Carter

BPO/mae